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ABSTRACT

Some crucial aspects of international scientific information systems whose establishment will be urgently required in the near future are explored. The exploration is concerned with futuristic aspects of the coming thirty-two years of the present century. The main sections of this report cover: (1) descriptions of the cybernetic era; (2) aspects of information problems (function, system and coordination) and (3) discussions of a world scientific information network system. (MM)

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INFORMATION SCIENCE APPROACHES TO SCIENTIFIC INFORMATION SYSTEMS AND THEIR IMPLICATIONS TO SCIENTIFIC RESEARCHES

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Information science approaches to scientific information systems and their implications to scientific researches

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Contents

1. Introduction

The purpose of this paper is to explore and to explain some crucial aspects of international scientific information systems which will be urgently required to be established in the coming days, and which, at the same time, can be expected to be realizable in near future in virtue of developments of information sciences and technologies. Our exploration and explanation are not so much concerned with the immediate applications of the contemporary computers and other information processors, but rather with futurologist aspects of the comming thirty two years of the present century and the twenty first one which can be coined by cybernetical era.

In section 2 we shall begin with a description of some features of cybernetical era as the background upon which our discussion will be built. The description will yield us indeed a general scope of information problems which we have to solve in the coming days. In order to find out any adequate approach to these information problems, we should analyse them into some essential aspects. This analysis is given in section 3. We shall point out that there are three essential aspects of our information problems, function, system and coordination aspects.

The analysis suggests us tomappeal to a set of two approaches both of which are indispensable for solving our infor-

mation problems. One of these two is an information science approach, while the other is a strategy approach.

Because of our emphasis placed on three aspects of the information problems, namely, function-system-coordination aspects, our solution does heavily rely upon a construction of scientific information system. It is from this standpoint that we shall discuss a (world) scientific information network system in section 4.

Section 5 gives a general summary of our conclusions given in this paper.

2. Information problems in cybernetical era

It was a few centuries ago when human civilization started to change its main feature, at least in advanced countries, from agricultural era to industrial one. Now we are in the process of the technology innovations with respect to computation, control and communication, which are coined as the 3c revolution. Some contemporary thinkers and scholars as well as many serious scientists and technologists have claimed that human civilization will turn out to transfer from the present industrial era to cybernetical era on a continuation of 3c revolutions whose influence will certainly become more and more broad and profound throughout all human activities now and in the coming days.

It is the purpose of this section to point out three characteristic aspects of information problems in such a cybernetical era with a preassumption of forthcoming of cybernetical era as a follower of the industrial one.

We are not intending to enter into a discussion of cybernetical era itself. The reader may refer to D. Bell [1], and C. R. Dechert [2].

2.1. Sciences, technologies and productions in cybernetical era

Nothing can exist in reality without matter end energy, and no production without materials and energies. Indeed the main applications of sciences and technologies to productions have been mainly considered from the stadpoint of material transformations and energy conversions for these few centuries of industrial era since the Industrial Revolution. However it has to be also admitted that no production can be performed without controlling matters and energies in the light of human knowledges.

Moreover, in view of the 3c revolution in our technologies, a revised recognition has been growing in these years to the effect that production in automation can be understood as an imbedding process of informations being carried by information processors into matters and engeries through some control processes. The recognition has been crystallised among many contem-

porary thinkers that information should be one of the indispensable production elements, that is, one basic constituents of production as matter and energy are so.

Furthermore we should proceed to assert that this recognition has its profound implications to the coming new industrial revolution as well as to the whole structural changes of sciences and technologies. Indeed it has been already observed as a matter of fact that information industries have been showing their magnificiant growth in these five years. Some scientists and technologists have been engaging with a working hypothesis that all engineering sciences can be constructed through some combinations of scientific and technological principles derived from the three basic technologies, namely material-, energy - information technologies. It has now become an urgent problem for managers, engineers and scientists to investigate the implications of the working hypothesis and to follow up their consequences, in order to find out an adequate strategy in research and development to with which to work in the coming days.

Furthermore a revolutionary classification of all industriaies can be expected to take place in which three basic technologies of materials, energies and informations will provide a guiding principle in coordination the current industries under the new frame of classification and in seeking for any drastic revolution of new industries to be created.

It is well hnown that the rôles of engineering sciences

were discussed by G. S. Brown [3] as early as in 1961.

It is expected to be one of the main features of new cybernetical era that, among these revolutionary changes of industries, information industries will have a dominant position in their rôles connecting all kinds of industries.

It seems to us to be crucially important for every scientist of the present time to have a penetrating recognition of the rôles of information science which will yield him so many channels of communications among different areas of sciences such as physical sciences, biological sciences, social sciences and humanities.

2.2. Human beings and their societies in cybernetical era

It is the purpose of this paragraph to point out some crucial effects of revolutions of sciences, technologies and productions to be expected in the coming days to human beings and their societies.

[1] Every member of societies will be required to have a continuous sequence of educations throughout his whole life so that he may be always qualified with abilities to work with and to manage with machineries and systems in cybernetical era. There will be a vast spread and tremendous popularization of higher educations to be achieved in schools and universities as well as after graduations from them. A remarkable increase of the ratio of the members of scientists and technologists

relative to those of other occupations will have been taking place in cybernetical era.

These anticipations enunciated by many authors such as N. Calder [4] and J. D. Bernal [5] and others should be one of the main factors in designing scientific information systems in the human learning societies which are to be adaptive to the progresses to be expected.

[2] On one hand we can expect to have so many feasibilities provided by information sciences and technologies in cybernetical era. On the other hand there will be social needs for introductions of so many informations systems combined with control and/or communication systems. It will not be absurd to imagine that current institutions for administrative, regulating, planning and commutations, which have been performed by such as parliament-diet, central and/or local governments and so on, would be replaced by a suitable set of information systems.

The present distributive pattern of human beings within a country can also be changed with the consequence that the sole function of urban area is to be a centre of social informations.

[3] Another crucial aspect of human societies is concerned with the rôles of nations which have been playing a predominant power over the social lives of human beings. It may be said that the appearances of cities, towns and urban areas in general

have had a great connection with production and distribution systems in agricultural era. In this line of thought we may present a working hypothesis that the apperances of modern nations and large countries with political powers for protecting raw materials against any enemy are at least partly due to the characteristic features of the industrial era in which acquisitions and monopolic possession of materials and energies in their utilization have to be exclusive to other ones. Now, if we consider a cybernetical era in which informations would be one of the predominant factors in productions and in societies, whay nations and countries should be required to exist and how they could be worth while to be maintained mingt become an important subject to be throughly investigated by scientists. In particular there remains unsolved an important research problem for information scientists to investigate a valuation system of informations and a right of information ownership. The two problems may become a matter of the deepest debate in organizing an international cooperation among scientists and technologists in establishing any scientific information system.

2.3. Challenging problems in front of cybernetical era

We have so far discussed technological feasibilities and their influences that can be imagined in the coming cybernetical era. It is, however, absolutely fantastic and unduely

naive to believe in a forthcoming of cybernetical era solely on the basis of a prospect of technical feasibilities and in the light of scientific possible achievements to be expected in the future. Indeed there do exist numerious difficulties that may happen to become serious enough to have the dangers of making human hopes to be ruined in vain, as Bernal [5] emphasized. We want to make it absolutely clear that we are neither saying that cybernetical era will certainly come nor claiming that the era, if it arrive, will promise to human lives happier than we have until now. All we have said hitherto are based upon the preassumption that it would have arrived. Indeed we should point out that it is indeed to be our keenest concern in the coming years whether and how any feasible solution to the following critical problems can be established by which to get out of human catastropy that may be involved.

Let us now mention some of the critical problems in front of us.

[1] Food shortage. The world scientists and technologists should be conscious of food storage in comparison with an increase of number of populations in the south. There is an absolute need for increasing the productivities of agricultures and industries in such a way that food shoratage problems can be sholved all over the world.

[2] International conflicts. We have already referred to a new aspect of international affairs which may be realized

in cybernetical era, because we can expect that some of the rôles of nations and countries will have been transferred to other institution owing to an invention of new information and control systems. However, in view of the present situation where atomic bombs and unclear forces can destroy human civilization with one mistaken message, we can not but argue that any effective cooperation of scientists and technologists all over the world should be urgently required to be established against any occurrance of mistaken message.

We scientists and technologists should also cooperate in scientific and technical approaches for solving unbalances between the south and the north, unbalances between the rates of economic developments of the south and the north, contradictions between urban and rural areas, and dangers of the world war. It is the consciousness of the responsibilities of scientists and technologists that should lead to a movements of establishing scientic information network system in the world.

[3] Conflicts between man and machine in cybernetical era.

The conflicts enunciated just now would be far more dangerous to mankind as a whole than the previous problems mentioned in the paragraphes [1] and [2]. Because of the anticipation that heroes of the machines in cybernetical era would be information processors in a general sense which can be specified by the capacity of having large amounts of memories and capability of learning and adaptation in view of accumulation

of their experiences. On one hand the utilization of these information processors could not be avoided. But on the other hand we always have to be conscious of the warnings given by the late Norbert Wiener [6], foundater of cybernetics, that machines can replace any specific work of human beings. In the coming days mankind should learn deeper and broader than be does now, in order that he would be well adaptive to the coming revolutionary changes of human societes, possibily with the minimal amount of sacrifices. This would give us the reason why scientific information system will be so urgently desired in our societies and this would also suggest us a set of evalulation criteria to measure the adequacies and the efficiencies of any scientific information system.

3. Three aspects of information problems

We have so far analysed some futurological aspects of the coming days and have shown the implications of cybernetical era and the challenging problems in front of mankind before his arrival at and during the cybernetical era. We have pointed out that the crucial reasons for establishing scientific information systems should be connected with our purose to solve these problems of urgent importance. Now it is our main job to endevour to find out approach for solving these challenging problems. Before doing this job we shall make an analysis of our problems from the standpoint of informations. The ana-

lysis yields us three aspects of information problems, namely, function-system-coordination aspects. Section 3.1 is devoted to the function aspects of informations in which an analysis will be given to three differents function aspects of information problems.

Subsection 3.2 is devoted to a discussion of system aspects of information problems by analysing information functions of some existing scientific information institutions. The notion of scientific information institutions is introduced here to make clear the essential common rôles of the existing institutions, with respect to information organizations, information transmissions and information uses. The introduction of this notion is correspondence with that of the notion of information industries by F. Machlup [7], which contain edcation, research and development in its domain.

Our discussion and analysis may be sufficient for our present purpose to emphasise that a system approach to the information problems is indispensable to our consideration on scientific information system. We shall suggest very briefly the possibility and the usefulness of system approach to scientific information systems.

Although each of various existing information institutions has a rather restricted domain of information functions, there now exists a remarkable tendency to amalgamate all of these functions into one total system as we can see in vision of

medical information system. A management information system (MIS) can be observed to be also another example of realizing the same idea, which, however, belongs to management area but not to science area.

In view of these facts it would be most useful to develop a system approach of the whole information institutions with respect to information functions.

System approach enunciated in subsection 3.2 will naturally lead us to the needs for a consideration of large system formation. Whether a system is large or small can not be absolutely defined. In order to explain our problem, we shall refer in section 3.3 to two recent trends in research and development in which either or both of international cooperations and interdisciplinary cooperations are urgently required.
A coordination principle based upon cooperations among scientific information systems, each of which has their respective purpose, is indispensable for a large system in our sense. This assertion will be given in section 3.3.

3.1 Function aspects of information problems

It is the purpose of this subsection to enunciate the scope and the implication of information functions which should be required in establishing our scientific information systems in the coming days. For this purpose it is convienent for us to analyse the whole function aspects into three constituents,

namely, information organizations, information transmissions and information services.

[1] Information organizations The following procedures are crucially important to organize our information storage and retrieval.

(a) Deduction procedure in augumenting storage of information. It is well known that simulation techniques have been used rather for pragmatic purposes to replace some experimental investigations by appealing to simulation models which serve to simulate, in some adequate approximation, the real phenomena in our concern with description given by a certain set of simulation languages adequate for the subject concerned. What we want to suggest now is to formulate simulation techniques so that they can be used as one indispensable instrument to augment our information storage by supplementing any information deducible from informations already having been obtained. Simulation techniques are applicable in virtue of model construction for our subject matter.

It is a remarkable tendency that so many simulations are now performemed by use of computers, and we can and we should expect that vast expansion of computer populations will more and more replace experimental works in laboratories as well as in field investigations, to say nothing about some of theoretical studies based mustly upon deductive reasonings.

(b) Reduction procedure in information organization In view of tremendous amount of information inputs, which we

should expect to recieve from human activities on researches, and developments, surveys and investigations and so on, we believe that it has already become an urgent requirement for us to invent some reduction procedure to be applied in organizing information so that we can extract an essentially new information from the coming original informations and to add merely the extracted essences to our storage of informations. Indeed it can be imagined that otherwise our storage of information would become an uncoordinated store of accumulations of knowledges and data for which no really efficient retrieval can be expected to be feasible.

To establish any reduction procedure for this purpose, it has both theoretical and practical implications to make clear a notion of essentially new information with reference to a specified domain of scientific informations. So far as we know, any systematic investigation does not seem to us to have been developed. In fact we rather think that there is an urgent need for an accumulation of experimental approaches in each individual field of science as well as for a systematic trial of theoretical investigations based upon theories of information sciences. In the meantime we should like to give a few comments on this extremely sophiscated and delicate notion.

Broadly speaking there should be some sort of criterium for nontriviality of informations as an approximate notion to

essentially new information which we imagine to be needed for.

A set of necessary conditions for nontriviality of information may consist of two conditions. The first condition is that a nontrivial assertion should be sufficiently well-formulated and should be expressed by a sufficiently short sentence in the languages of the subject sciences concerned. The second condition is that it should not have a short deductive proof which can be formed by the informations obtained from the existing storage of informations.

(c) Self-organizing procedure applied to storage of information Now having two procedures explained in (a) and (b), there is a need for our information storage to have a self-organizing procedure by which to reorganize, if necessery, our storage in view of non-trivial new information added to the old storage.

Such a reorganization may lead us to a new criterium of non-triviality, because some non-trivial informations may be reduced to trivial ones and should be excluded in view of the new included informations. This implies that our storages of informations are always subject to a possibility of reorganization and that non-triviality and triviality can be interchanged through such reorganization. This is nothing but what we should call a reorganizing procedure to be applied to storage of information. The idea was pointed out by V. H. Glushkov [8]. We can expect that advances of computers will make it possible to provide us an automated process of reorganizing

procedures, which we may call a self-organizing procedure applied to a storage of information.

(d) Learning procedure in information storage

The combined functions on the basis of three procedures, namely deduction, reduction and reorganization explained just now in the preceeding paragraphs, will give a new image of information storage drastically different from the present notion of information storage embodied by liberaries and documentation centers. What we want to emphasise here in connection with function aspects of informations is that we should start with a reconsideration of science methodologies applied throughout all branches of sciences, natural, social and humanistic.

Science methodologies are understood to have been based upon elaborations and evolutions of logics of deduction, induction and abduction indicated by Aristoteles. Now the time has become when we should ask whether and how some of these methodologies can be transferred to the rôles of information processors.

In this connection the author of the present paper discussed the rôles of so called automated statisticians in his paper T. Kitagawa [9] where a lot of the literatures due to J. Tukey [10], M. G. Kendall and P. Wegner [11] and Cooper [12] can be found.

It is remarked that automated mathematicians proving geometrical theorems, automated statisticians dealing with

statistical data analysis, and automated laboratory research workers using on line computers for gathering and analysing observational data have been already, in some extent, realized through the current uses of computers. It is true that most of them are concerned with science methodologies based upon deduction and induction, but not so much on abduction which is more deeply connected with human creative thinking. However we should add to say that an investigation has been already started by us regarding computer application to deal with some sort of abduction. The author of the present paper pointed out in his recent paper T. Kitagawa [13] the uses of abduction in information organization problems.

In view of these recent trends of science methodologies it is a matter of urgent importance to take into our consideration all the four procedures (a), (b), (c) and (d) in setting up any scientific information system in the coming days.

[2] Transmission of information In spite of the apparent defferences among their technical frames and their emphases, school educations, broad casting systems and other mass communications have at least one common function of information processing, namely, transmission of information. In this paper we shall not be concerned with system aspects of these institutions, but entirely with function aspects of transmission of information in our social activities.

Now it is our basic recognition that people in cybernetic

era should be provided with a social system of continuous education throughout their lives, irrespective of their occupations and their social positions. In this point of views it will be worth while to observe the present situation of information transmissions in our societies. The present situation is this. Pattern recognitions based on well organized information are being provided by schools and universities, but substantially only within the period of students, while a tremendous flows of rather fragment sequences of informations are being given by mass communications throughout the whole span of their lives, mostly, if not entirely, without no systematic educational effects on their pattern recognitions. We are conscious of being somewhat exaggerating our views to the extent that some educational rôles of the current broad casting systems and mass communications may seem to be unduly omitted. However it can not be denied that these current educational functions being performed by social institutions will not be sufficient enough to satisfy the scopes and the depths of systematic social professional educations and ones needed for a person to be a membership of cybernetical era.

Now turning to the technical feasibility of extended social education systems as transmission systems of both organized and unorganized informations there are two indispensable aspects of the techniques, namely, hardware aspect and software aspect. Both of these two technology aspects seem to us very promising

and hopeful for satisfying our demands. Sepecially for transmission of unorganized informations in our terminology various sorts of planns and proposals have been already presented to the public by information technologists, showing the feasibility of supplying flows of such informations through information lines spc..sored by an Information Service Authority whose idea corresponds to public services now being given by Electricy Authorities and by Telephone Authorities and so on. However with regard to organized informations the story is quite different. So far as we know no systematic investigation has not been published in any literature. It is such a situation when we should have a vision of any information transmission system in the coming days. Any scientific information system can not but have a very intimate connection with other systems of information transmission.

In cybernetical era people will be clearly conscious that education should not and can not be restricted within campuses of schools and universities and that teachers and professors may not necessary come from schools and universities. It is one of the crucial requirements in cybernetical era that social information transmission systems should be established through which they can and should learn so as to make them always ready to be adaptive to revolutionary changes of social patterns. It is in this era that so called education is definitely a synonym to social system of transmissions of organized information which

serves people to make and to reform their recognition pattern at any stage of their lives.

[3] Utilizations of informations In cybernetical era there will be seen some social changes of utilization pattern of informations. Specifically we shall observe the following remarkable tendencies:

(1°) a tremendous increase of numbers of users and of the volumes of demands for uses of information

(2°) a more extensive utilization of various sources of information: researches, developments, surveys, investigations and by other projects

(3°) a more intensive utilization of organized informations ranging over vast fields of differnt sciences and technologies

(4°) an increase of demands for information services satisfying the social trends enunciated in (1°), (2°) and (3°).

These tendencies would lead us to the conclusion that some adequate information service system should be designed and be set up so as to satisfy the needs shown be these tendencies. Looking back to the present information service systems around us, we are sure that almost all our needs have not been satisfied by them and moreover we are anxious to say that, without any definite progressive step of reconstructions and revolutionary changes of our current notions, we could neither be so optimistic to believe that these needs would be satisfied merely by libraries and documentation centers now existing,

nor could be so unrealistic to clain that drastic changes should be introduced to their functions with possible sacrifices loosing their traditional characteristic merits which human societies have succeded to establish through accumulation of experiences of more than ten centuries. We should rather set up a coordination sheme under which the existing institutions of science information service shall be included as one component system in the entire total system in such a way that their traditional merits can well be kept to work in. This does by no means imply that we should be conservative in introducing a new subsystem of giving information services satisfying our requirements.

3.2. System aspects of information

In this subsection we shall consider system aspects of information institutions with reference to information function aspects enunciated in the preceding subsection. By information institutions we mean such existing institutions as research institutes, academic societies, libraries, universities, schools and production plants and so on. The reason why we call them as such is simply because each of them is concerned with at least one of the following aspects of informations functions:

(i) Production of original source informations which are candidates for essentially new information (abbreviated by source production)

(ii) Formation of essentially new informations with reference to a frame of the specified store of information (abbreviated by new formation)

(iii) Publication of essentially new informations in the form of documents (abbreviated by new publication)

(iv) Storage of informations

(v) Organization processes of informations which may lead to recognition formulation of deductive theory and/or systematic frame of descriptions of the subjects (Recognition formations and organization)

(vi) Transmission of recognitions

(vii) Utilizations of recognitions and informations to operational purposes (Uses of recognitions).

By virtue of these seven aspects of informations whose classification are not satisfactory to be disjunctive to each other but still at least convenient for the present purpose of analysing the existing institutions, we can obtain Table I showing the breakdown of function aspects of informations shared by these institutions.

Although Table I yields us no more than an approximate picture of real circumstances, it is worth while to observe from this that each of these institutions share a very restricted domain of functions of information handling as division of labours and that coordination does not seem to be strong enough to realize the cooperative works among all these insti-

tutions. See Perkins [14] for reference.

Now let us turn to two recent examples of information systems, namely, medical information system on one hand and management information system on the other hand.

The idea of medical information system has been proposed by many biological and medical scientists and physicians in several advanced countries in the east and in the west. It is in some respect due to the merits of MEDLARS which has lead some of these experts to this idea. It is to be noted that medical information system can be recognised as a consolidated total system covering all function aspects of informations.

Now regarding management information system (abbreviated by MIS) the conclusion can be more explicitly and more clearly explained, because it is the idea and the aim of MIS which leads management people and computer makers to this idea and which are explicitly enunciated as a total system possessing all the functions of informations ranging from (1°) to (7°).

Table II-1 and II-2 provide us with the explanations we have given just now.

Table I Institutions and systems with reference to information

	New information production			Storage of informations	Recognition formations and organization	Transmission of recognitions	Uses of recognitions
	Source production	New formation	New publication				
Research institute	●	●					
Academic society		●	●				
Library				●			
University (research)					●		
University (education)						●	
University (service)							●
School						●	
Plant							●

Table II-1 Medical Information System

	New information production			Storage of informations	Recognition formations and organization	Ttansmission of recognitions	Uses of recogni-tion
	Source production	New formation	New publication				
Clinics	●						●
Hospitals	●			●			
Medical research Institute	●	●			●		
Medical Society		●	●				
Medical Library				●			
Medical Department in univer-sity	●	●		●	●	●	●
Medical school						●	●

Table II-2 Management Informations System

	New information production			Storage of informations	Recognition formations and organization	Transmission of recognition	Uses of resogni-tions
	Source production	New formation	New publication				
Laboratory	●	●					
Pilot plant	●	●					
Library				●			
Technical section				●	●		
Production section				●	●		●
Management school and training						●	
Marketing	●						

3.3. Coodination aspects of information problems

Coordination aspects of information problems are concerned with our central problem how to coordinate various constituent information systems so that we can have either one large system or an aggregate set of subsystems which can satisfy as a whole the requirements for information functions such as discussed in subsection 3.1.

To illustrate our problem, let us consider a university which has many faculties, many research institutes, several libraries within its campass. For instance Harvard University is said to have adopted a decentralised coordination of many libraries in its campass, in stead of centralisation, after its long experiences. Similar information coordination problems have already become serious not only within and beyond one university, but also within and beyond one specific area of natural and social sciences. Moreover the information coordination problems are now being raised by many existing scientific organizations throughout the world, requiring coordination not only within one nation but also in international frame work. In this connection we shall now present several important features that should be taken into our serious considerations with particular reference to the coming cybernetical era.

[1] International cooperation for information coordination

This will be possible because we shall be equipped with innovations in information technologies in the coming cybernetical era. This will be required because we shall be in front of various serious problems to besolved in human societies. Without any establishment of international coorperation for information coordination manking can not solve so many conflicting problems such as enunciated in section 2. On one hand an establishment of international cooperation for information coordination will be a result of international cooperation in solving these crucial problems. On the other hand an establishment of international cooperation for information coordination will give as well as a stimulus for fostering to implement such an international cooperation.

[2] Interdisciplinary cooperation

The recent developments of information sciences and technologies have been introducing resolutionary changes in research and development methodologies, as we can observe in laboratory automations, design automations, hospital automations and simulation language techniques.

It can be admitted that in any large scale scientific research and big technological development we can scarecely adhere to any one isolated division in the sense of the traditional classification of sciences and technologies. This implies that there is an urgent need for establishing a coordination among individual specialised information centers in order

to be useful for these researches and developments. However the essential features of interdisciplinary cooperations in cybernetical era may be deeper than what we have mentioned, become it will be one of the characteristic features of the era that classification of all sciences and technologies may not be as they have been since these last two centuries. That is to say, we can no longer adhere to the traditional classification of sciences and technologies but it may be said that we are now taking one pragmatic step in advance as one approach to this problem by establishing interdiciplinary cooperations among various divisions of sciences and technologies, before we can give an adequate new revolutionary classification, without knowing whether or not the traditional classification may be valid in the future.

4. Proposal of two approaches

So far we have given an analysis of scientific information problems in cybernetical era. Now it is our job to show a general outline of possible approaches for solving these problems in front of us.

First of all we should emphasise a need for adopting a systematic methodology in solving these problems. Among systematic methodologies now available to us, we can recommend a method which has some similarities with operation research

method. Its essential aspects may be outlived in what follows.

(1°) A set of conditions for our goal should be clearly defined.

(2°) Our present state should be objectively described.

(3°) A set of strategies by which to transform our present state into a state satisfying the set of conditions for our goal should be definitely given.

(4°) A set of conditions restricting the set of strategies so as to be feasible should be assigned.

This desoription is so broad that the scheme can contain an operation research as well as project control as its special cases. Moreover it should be mentioned that dynamic programming and adaptive control are contained in this scheme.

Let us now discuss some aspects of these four points (1°), (2°), (3°) and (4°).

Ad(1°). It is indispensable to make clear a set of conditions for our goal in designing scientific information systems. First of all we should enumerate a set of all possible kinds of users of our scientific information systems and we should investigate what they want to be served by scientific information system.

In some respects their requirements for services provided by scientific information system may be common among themselves and coincident with each other, while in other respects they may be different and furthermore sometimes may be conflicting

with each other. These complicated situations show the needs for an objective description of conditions for our goal, which is neither so trivial nor so easy as one may imagine before starting the work.

Ad(2°). Once we shall have succeded in an objective description of a set of conditions for our goal, this fact will make us possible or at least easy to describe our present state, by means of descriptors which will have been proved to be usefull in the objective description of the set of conditions for our goal. These descriptors may turn out to be a set of parameters, $x=(x_1, x_2, \cdots, x_n)$. Thus in such cases our goal can be denoted by a particular vector $a=(a_1, a_2, \cdots, a_n)$ belonging to a certain set of parameter values $\mathcal{A}: a \in \mathcal{A}$, while the present state by another vector $p=(p_1, p_2, \cdots, p_n)$, presumably belonging to a certain set $\mathcal{B}: p \in \mathcal{B}$.

Ad(3°). It will not be difficult to understand the notion of a set of strategies. For instance when descriptors are given by parametric representations as given in (2°), the set of our strategies may be denoted by $S=\{s\}$, where s is one of our strategies. Here strategies are understood in the broadest sense. For instance with reference to dynmic programming approach or to adaptive control approach each one strategy s may be actually a sequence of sequential operations $s=(s_1, s_2, \cdots, s_n)$ in which the n-th stage operation s_n may be determind in view of informations obtained by previous applications of

operations (p, s_1p, s_2s_1p, $s_3s_2s_1p$, $\cdots$, $s_{n-1}s_{n-2}\cdots s_1p$). This is merely one example. There are quite a lot of other possibilities.

Ad(4°). A set of strategies given by (3°) is rather concerned with technical posibilities. Therefore in order to have a set of feasible solutions to our problem it is indispensable to have a set of conditions restricting the set of strategies so as to be feasible.

In combination of these four conditions (1°), (2°), (3°) and (4°), our task becomes something like a traveler problem whose destinations area $\mathcal{Q}$ and departure area p are assigned and whose feasible travel route is restricted within the area $\mathcal{B}$. He can travel by any combination S of transportation facilities admitted to be used.

The problems are as follows:

(a) Whether or not be can reach the destination area $\mathcal{Q}$?

(b) How efficiently he can reach the destination area $\mathcal{Q}$?

It is noted that some criterium should be given in order to answer to the problem (b), as we can see in any mathematical programming and any control theory approach.

We are not entering into the mathematical details of such formulation, but we are now rather concerned with some aspect of (3°) and with our learning approach attitude. That is to say, we are now going to discuss two important proposals in our approaches, which will be discussed in the following two

subsections 4.1 and 4.2.

4.1. Information science approach

A formulation of scientific information system and its realization should be given in our cybernetical revolution era when information sciences, information technologies and information industries are bing in the stage of accelerated rapid development and innovations. This fact makes our job to be similar to rather something like project control than to an ordinary job of operations researches, because our strategies themselves are subject to revolutionary changes during the course of transition for departure area to destination area.

It can be safely said that we cannot emphasise too much the needs for our readiness and adaptiveness to employ any revolutionary information technology which can be useful to our scientific information system. But this is not sufficient enough as our attitude. In designing a formulation of our scientific information systems and in promoting its realization, we should be so progressive and so positive that we shall make analyse a set of conditions for our goal in such a way that requirements and demands to information science and technology can be deduced from the set of conditions for our goal. This remark is quite important, because without any adequate description of our goal for scientific information system in terms of information technologies there

would be always underlying dangers of having no definite aims for researches and developments in some area of information sciences and technologies and hence trying to attain at too idealistic aims having no practical implications with reference to the conditions for our goal.

Information science will give a revolutionary effects to almost all branches of natural and social sciences as well as humanities, and these effects are expected to be given by various scientific information systems. In this connection a systematic description of information science approach in designing and scientific information system is of the almost importance in the coming days. For information science see Kitagawa [15].

4.2. Strategy approach

Another aspect of our approaches is indispensable in designing a formulation of scientific information systems and in promoting their realizations. This is a strategy approach to our problems. We should pay our attentions to real circumstances of the present state of scientific research activities and scientific information cooperations in the world. In order to choose an adequate course of evolutions in our scientific information system, the ICSU should prepare a systematic survey of the present state scientific research activities and in co-

nnection with the possibilities of automations of laboratory works, observation works and data acquisitions.

Technical innovations will involve revolutionary changes in scientific methodologies regarding these activities of scientists, which turn out to yield a new set of requirement of scientific information system. In these circumstances it is crucially important to establish our strategic approach so as to be sensitive to such innovations and to be adaptive to them by learning any useful development of information sciences and technologies. We should be clever enough to learn by experiences, and should be the most far from the rigid concepts of information system based upon any fixed stage of development of information sciences and technologies.

In this consequence we want to assert that the most urgent problem for us in considering world scientific information system is not so much concerned with any definite plan rather with any establishing how to organize a systematic learning process by which first to accumulate various expriences in every country and in every branch of sciences and technologies and secondly to deduce any adequate conclution in formulting and realizations of scientific information system. To be more specific in our proposals, we want to summarize our viewpoints in the last section 5.

5. Conclusion

In conclusing this paper it may be adequate to propose some specific proposals along the lines which we have explained in our discussion.

Proposal 1. ICSU should organize a sequence of systematic surveys covering all sciences and technologies on the progresses of

(a) laboratory automation

(b) statistics automation

(c) documentation automation

(d) library automation

(e) hospital automation,

on the annual basis, through cooperations with various international scientific organizations as well as with national ones.

Proposal 2. ICSU should organize a sequence of symposia and seminaries on information science and technologies on a certain regular interval of times, with particular emphasis on the topics such as

(a) function of information processings

(b) information systems

(c) coordination of information systems,

both from hardware aspect and from software one, with cooperations of adequate intervational scientific societies.

Proposal 3. ICSU should have a scheme to help in sett-

ing up model scientific information systems in various countries and in various fields of sciences and technologies, from which real data can be presented to discussions in symposia and seminaries mentioned in Proposal 2.

Proposal 4. ICSU should have a plan of simulation experiments of scientific information systems for crucial issues of debates which have been presented in symposia and seminaries suggested in Proposal 2, as well as for various problems raised through observations from a sequence of surveys given by Proposal 1.

Proposal 5. ICSU should start with an establishment of committee and a sequence of particular symposia for reviewing the activities of sciences and technologies in order to discuss any possible introduction of new classification of all natural and social sciences and technologies as well as humanities in the cybernetical revolution.

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